SOURCE TEST PLAN
2018 Ethylene Oxide Test Program
Terumo BCT, Inc.
Lakewood, Colorado

Prepared For:

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For Submittal To:

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Document Number: **043AS-484549-PP-123R1**
Proposed Test Date: **October 29 through November 5, 2018**
Submittal Date: **October 26, 2018**

STAC
STACK TESTING ACCREDITATION COUNCIL
A2LA ACCREDITED
TO ASTM D7036 ONLY
CERT #3925.01

MONTROSE
AIR QUALITY SERVICES

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Project Overview

General

The procedures outlined in this test protocol cover the air emissions test program to be conducted at the Terumo BCT, Inc. (Terumo BCT) facility located in Lakewood, Colorado. The specific objectives of the test program are to:

- Monitor the emissions of ethylene oxide (EtO) from the scrubber outlet and adsorber outlet for a period of seven (7) days
- Periodically monitor the emissions of EtO from the scrubber inlet and adsorber inlets (2)
- Perform ambient air canister sampling for EtO at four (4) locations for a period of seven (7) days

Testing will be conducted to meet the requirements of Terumo BCT; the Colorado Department of Public Health and Environment (CDPHE); and the United States Environmental Protection Agency; as applicable. Testing will be conducted by Montrose Air Quality Services, LLC. (MAQS). Coordinating the test program will be:

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Methodology

EtO Emissions Testing Methodology

The emissions of EtO at the adsober and scrubber stacks will be determined using EPA Method 320. In Method 320 a sample of the gas stream will be withdrawn from the test location at a constant rate through a heated Teflon sample line and passed directly into a gas analyzer that utilizes Fourier Transform Infrared (FTIR) spectroscopy.

To convert the EtO concentrations to mass flow rates, the volumetric gas flow rate will be determined at each test location using EPA Methods 1 and 2. Because of the variable nature of the gas flow rates, the gas flow rate and temperature will be continuously monitored using pitot tubes mounted in the stacks. To determine the location of the pitot tube, a preliminary flow traverse will be conducted and the pitot placed at a point that best represents the average gas velocity. Due to the ambient nature of the test locations, the carbon dioxide and oxygen concentrations will not be determined and the molecular weight will be assumed to be 29.0 as allowed by EPA Method 2, Section 8.6. The moisture content will be periodically determined using the wet bulb/dry bulb technique.

Sampling will be conducted at the two (2) outlet locations for a period of seven (7) days. Additionally, Montrose will test periodically throughout the week test at the inlet test locations to determine the removal efficiencies of the scrubber and adsorbers. Please note that the scrubber inlet testing will be conducted for EtO only with no volumetric flow determinations. Removal efficiency at the scrubber will be based upon concentration only.

EtO Ambient Testing Methodology

EPA Method TO-15 will be used to determine the concentrations of EtO from five (5) sites near the facility. The locations will be as follows

- One (1) downwind fence line location
- One (1) upwind fence line location to determine background
- Three (3) community locations

The downwind and upwind site locations will be determined based upon modeling. A gas sample will be collected from each site into a Summa Canister over a period of 24 hours for each of seven (7) days (35 samples total). Additionally, two (2) blank and two (2) split samples will be collected and analyzed.

Sampling canisters will be provided pre-cleaned and certified by Enthalpy Analytical. Prior to sampling, the canisters will be individually certified. Canister sampling will be conducted using an Entech Instruments Silonite™ CS1200E Passive Canister Sampler or equivalent.

Parameters

The following gas parameters will be determined at each source test location. Additionally, EtO will be determined at the five (5) ambient locations.

- duct temperature
- moisture concentration
- gas velocity
- volumetric flow rate
- EtO concentration

Test Schedule

Testing is currently scheduled for October 29 through November 5, 2018 pending approval from CDPHE. Testing will be performed according to the following schedule of activities. The inlet testing is not shown on this schedule and will be conducted during the week days.

Date	Location	Activity	Test Method
10/29	Lakewood, CO Adsorber & scrubber stacks Ambient locations	Setup test equipment Start monitoring - noon Start canister sampling – noon	 1, 2, 320 TO-15
10/30	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
10/31	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
11/1	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
11/2	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
11/3	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
11/4	Adsorber & scrubber stacks Ambient locations	Continue monitoring Swap canister samples - noon	1, 2, 320 TO-15
11/5	Adsorber & scrubber stacks Ambient locations	End monitoring - noon End canister sampling - noon Breakdown equipment	1, 2, 320 TO-15

Test Procedures

Method Listing

The test methods found in 40 CFR, Part 60, Appendix A as well as the “Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition” will be referenced during the test program. The following individual methods will be referenced:

Method 1	Sample and Velocity Traverse for Stationary Sources
Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Method 320	Method 320 - Vapor Phase Organic and Inorganic Emissions by Extractive FTIR
Method TO-15	Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography / Mass Spectrometry (GC/MS)

Method Descriptions

Method 1

EPA Method 1 will be used to determine the suitability of the test locations and to determine the traverse points used for the volumetric flow rate determinations. The test locations must conform to the minimum requirement of being at least 2.0 diameters downstream and at least 0.5 diameters upstream from the nearest flow disturbances.

Method 2

EPA Method 2 will be used to determine the gas velocity through each test location using a Type S pitot tube and an incline plane oil manometer. The manometer will be leveled and “zeroed” prior to each test run. The sample train will be leak checked before and after each run by pressurizing the positive side, or “high” side, of the pitot tube and creating a deflection on the manometer of at least three in. H_2O. The leak check will be considered valid if the manometer remains stable for fifteen (15) seconds. This procedure will be repeated on the negative side by generating a vacuum of at least three in. H_2O. The velocity head pressure and gas temperature will then be determined at each point specified in Method 1. The static pressure of the duct will be measured using a water filled U-tube manometer. In addition, the barometric pressure will be measured and recorded.

Because of the variable nature of the gas flow rates, the gas flow rate and temperature will be continuously monitored using pitot tubes mounted in the stacks. To determine the location of the pitot tube, a complete flow traverse will be conducted and the pitot placed at a point that best represents the average gas velocity. The Method 2 sampling apparatus is shown in Figure 1 in the Appendix.

Method 320

The EtO concentrations at each test location will be determined using EPA Method 320. In Method 320, a sample of the gas stream will be continuously withdrawn from the test location and analyzed using a continuous FTIR gas analysis system.

The sample gas will be withdrawn from each test location at a constant rate through a stainless-steel probe, a heated glass fiber filter and a heated Teflon sample line. The probe, filter and sample line will be operated at a temperature of 200°F or greater to prevent the condensation of moisture. The wet gas will then be directed to the FTIR spectrometer gas cell. Results from the analyzer will be determined on a "wet" volume basis.

The FTIR gas analyzer that will be used for this project is an MKS MultiGas FTIR analyzer and a schematic of the sampling system can be found in Figure 2 in the Appendix.

Prior to testing, the detection limit (DL) and analytical uncertainty (AU) will be determined for each constituent. The potential interferants for the analytes being tested will be determined. The optical configuration that can measure all of the analytes within the absorbance range of 0.01 and 1.0 will be determined. The sample system will be assembled and allowed to reach stable operating temperatures and flow rates. A sample interface leak check will be performed. Nitrogen or zero air will be directed to the FTIR gas cell to determine a background spectrum. A sample spectrum will then be recorded in succession. The peak to peak and RMS noise in the resultant spectrum in the wavelength region(s) to be used for the target compound analysis will be measured and recorded.

A Calibration Transfer Standard (CTS) will be introduced into the system and two spectra will be recorded at least two minutes apart. If the second spectrum is no greater than the first and within the uncertainty of the gas standard, it will be used as the CTS spectrum.

A QA spike will be performed by introducing a certified standard of EtO into the sampling system. First, some of the effluent gas will be sampled to determine native concentration of target analytes. The analyte spike calibration gas will then be introduced to the FTIR gas cell only, and the results will be determined using the analytical algorithm. Results from the calibration gas will be recorded and compared to the certified value of the calibration gas. For reactive condensable gases such as hydrogen chloride (HCl), ammonia (NH3), and formaldehyde (HCHO), the results must be within 10% or 5 ppm. For RATA class gases, the FTIR results should be within 2% of the certified value. The analyte spike calibration gas will then be directed through the entire sampling system and allowed to mix with effluent gas sample at a known flow rate. The flow ratio of calibration gas to ambient air or source effluent shall be no greater than 1:10 (one-part calibration gas to ten parts total flow) for the determination of sample recovery. Spectra will be recorded for three non-consecutive spiked samples and the concentration of the spike will be calculated. The average spiked concentration must be within 70% and 130% of the expected concentration.

After all the required pre-test procedures have been performed, stack gas will be sampled continuously. Sample interferograms, processed absorbance spectra, background interferograms, CTS sample interferograms, and CTS absorbance spectra will be recorded. Sample conditions, instrument settings, and test records will also be recorded throughout the test. If signal transmittance changes by five (5) percent or more in any analytical spectral region, a new background spectrum will be obtained. A new CTS spectrum will be obtained after each sampling run. The post-test CTS spectrum will be compared to the pre-test spectrum. The peak absorbance from each spectrum must be within five (5) percent of the mean value.

Method TO-15

EPA Method TO-15 will be used for the ambient EtO concentration determinations. In TO-15, a sample of the gas stream is withdrawn at a constant rate through a stainless steel probe. An evacuated, passivated stainless steel canister and a vacuum regulator will be used to collect an integrated sample over the entire sample run. The canister will be approximately six (6) liters in volume and the vacuum regulator will be set to collect a full sample in 24 hours.

Sampling canisters will be provided pre-cleaned and certified by Enthalpy Analytical. Prior to sampling, the canisters will be individually certified. Canister sampling will be conducted using an Entech Instruments Silonite™ CS1200E Passive Canister Sampler or equivalent.

At the conclusion of each test run, the sampling canister will be recovered, sealed and shipped to the laboratory. The samples will be analyzed using gas chromatography coupled with a mass selective detector (GC-MS) by Enthalpy Analytical, Inc. at their laboratory located in Durham, North Carolina.

Description of Installation

Overview

Terumo BCT, Inc. operates a six (6) chamber sterilization facility in Lakewood, Colorado. Products to be sterilized are placed in a sterilization chamber and are exposed to a sterilant gas (EtO) at a predetermined temperature, humidity level, and pressure. The EtO penetrates product packaging (e.g., cardboard shipping box, plastic shrink wrap, paper box, and product wrapping) and destroys bacteria and viruses on the product. The product remains sterile until use because bacteria and viruses cannot penetrate the product wrapping.

Process Description

The typical sterilization cycle consists of six phases: (1) pre-sterilization conditioning, (2) sterilization, (3) evacuation, (4) air wash, (5) chamber exhaust, and (6) aeration. Each of these phases is discussed briefly below:

After the products have been loaded into the chamber and the airtight door is sealed, a partial vacuum is drawn inside the chamber. This initial vacuum, or drawdown, prevents dilution of the EtO. The chamber temperature and relative humidity is adjusted to ensure proper sterilization, The EtO is introduced into the chamber to achieve the desired concentration of EtO.

Following sufficient exposure time, the EtO is evacuated from the chamber with a vacuum pump. This post-cycle vacuum phase typically lasts about 25 minutes. The pressure in the chamber is then increased by introducing air. The combination of evacuation and air wash phases is repeated multiple times to remove as much of the EtO from the product as possible. The purpose of the air washes is to allow residual EtO to diffuse from the product.

At the end of the sterilization cycle the chamber is returned to atmospheric pressure by introducing air. When the chamber door is opened to unload product, the rear chamber vent system is activated to prevent the sterilization operators from being exposed to elevated levels of EtO that may be present inside the chamber

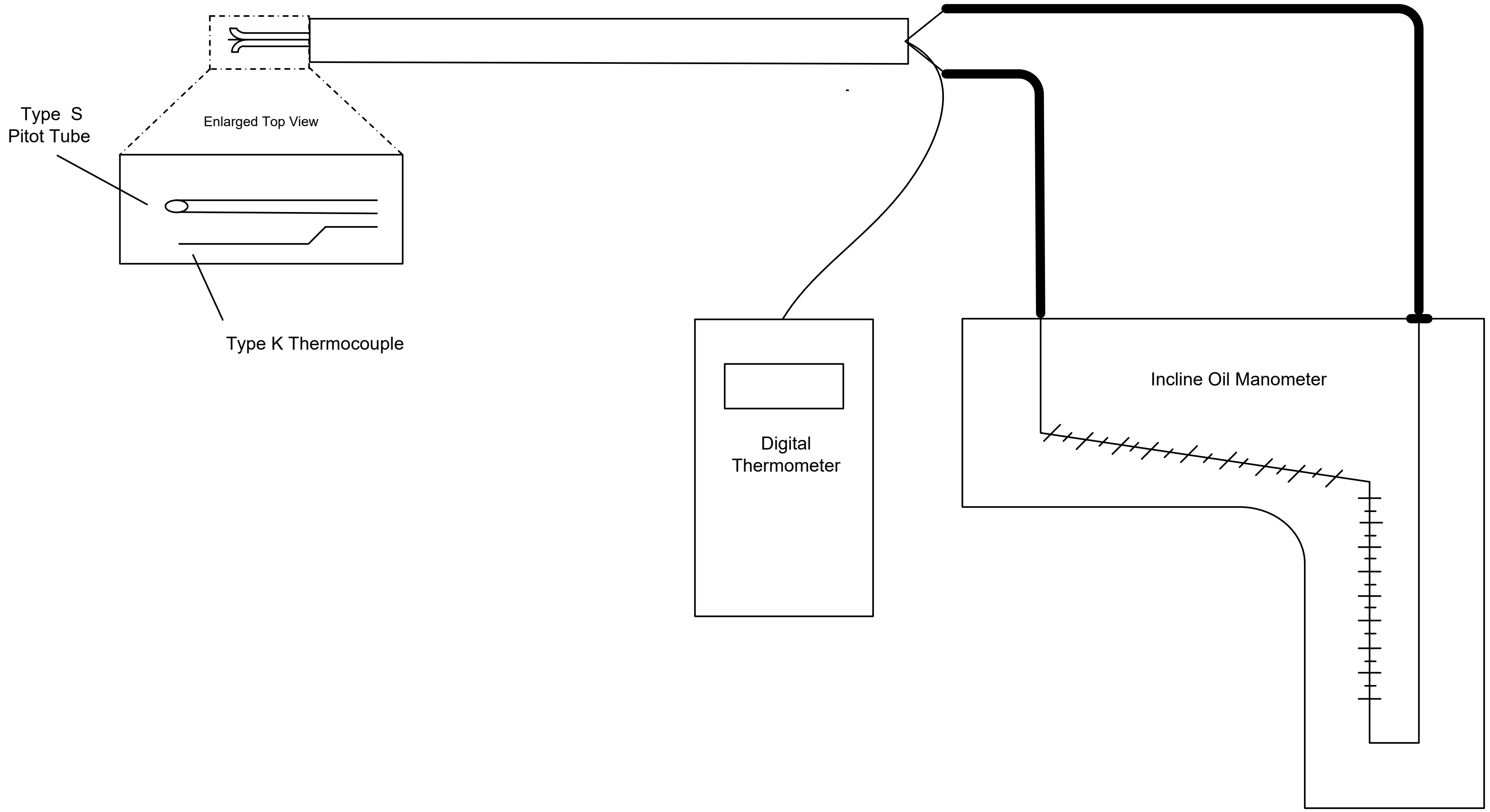
Following their removal from the sterilization chamber, the sterile product are placed in an aeration room and kept there for several hours or days depending on the product. The purpose of aeration is to allow further diffusion of residual EtO from the products prior to shipping in order to comply with the FDA and EPA guidelines for residual EtO.

Control Equipment

The sterilization vacuum pumps are ducted to a packed scrubber for removal of EtO. The aeration room and sterilization back vents are ducted to adsorbers for removal of EtO.

Appendix

Figures



EPA Method 2:
Type S Pitot Tube Assembly with Manometer

Figure 1

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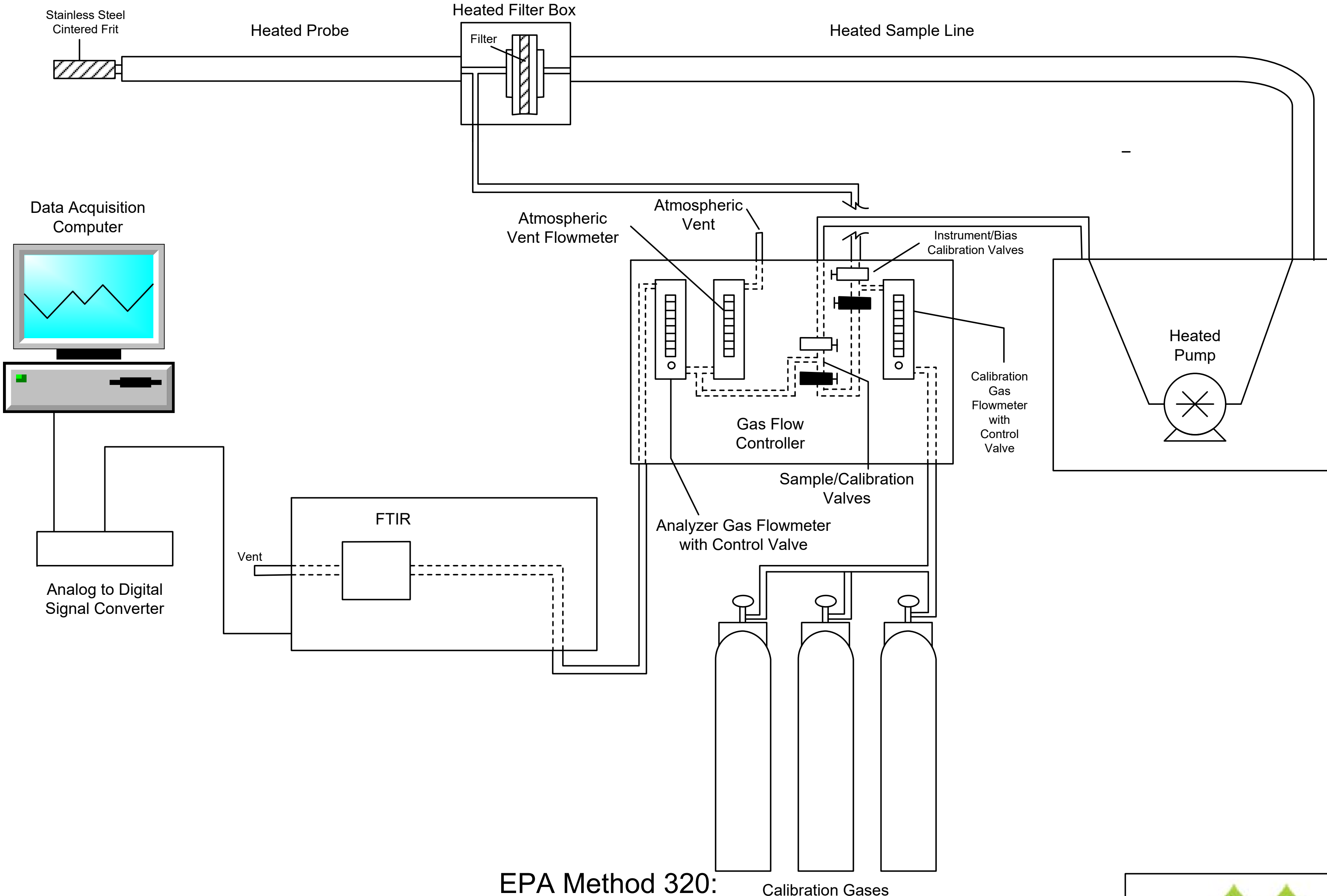


EPA Method 320:
EtO FTIR Sampling Train

Figure 2

Sample Calculations

Area of Sample Location

$$A_s = \pi \times \left(\frac{d_s}{2 \times 12} \right)^2$$

where:

A_s	= area of sample location (ft^2)
d_s	= diameter of sample location (in)
12	= conversion factor (in/ft)
2	= conversion factor (diameter to radius)

Stack Pressure Absolute

$$P_a = P_b + \frac{P_s}{13.6}$$

where:

P_a	= stack pressure absolute (in. Hg)
P_b	= barometric pressure (in. Hg)
P_s	= static pressure (in. H_2O)
13.6	= conversion factor (in. H_2O/in Hg)

Molecular Weight of Dry Gas Stream[1]

$$M_d = \left(44 \times \frac{\%CO_2}{100} \right) + \left(32 \times \frac{\%O_2}{100} \right) + \left(28 \times \frac{(\%CO + \%N_2)}{100} \right)$$

where:

M_d	= molecular weight of the dry gas stream (lb/lb-mole)
$\%CO_2$	= carbon dioxide content of the dry gas stream (%)
44	= molecular weight of carbon dioxide (lb/lb-mole)
$\%O_2$	= oxygen content of the dry gas stream (%)
32	= molecular weight of oxygen (lb/lb-mole)
%CO	= carbon monoxide content of the dry gas stream (%)
$\%N_2$	= nitrogen content of the dry gas stream (%)
28	= molecular weight of nitrogen (lb/lb-mole)
100	= conversion factor

[1] The remainder of the gas stream after subtracting carbon dioxide and oxygen is assumed to be nitrogen.

Molecular Weight of Wet Gas Stream

$$M_s = \left(M_d \times \left(1 - \frac{B_{wo}}{100} \right) \right) + \left(18 \times \frac{B_{wo}}{100} \right)$$

where:

M_s	= molecular weight of the wet gas stream (lb/lb-mole)
M_d	= molecular weight of the dry gas stream (lb/lb-mole)
B_{wo}	= moisture content of the gas stream (%)
18	= molecular weight of water (lb/lb-mole)
100	= conversion factor

Velocity of Gas Stream

$$V_s = 85.49 (C_p) \left(\sqrt{\Delta P} \right) \sqrt{\frac{(T_s + 460)}{(M_s)\left(P_b + \frac{P_s}{13.6} \right)}}$$

where:

V_s	= average velocity of the gas stream (ft/sec)
C_p	= pitot tube coefficient (dimensionless)
$\sqrt{\Delta P}$	= average square root of velocity pressures (in. H_2O)$^{1/2}$
T_s	= average stack temperature (°F)
M_s	= molecular weight of the wet gas stream (lb/lb-mole)
P_b	= barometric pressure (in. Hg)
P_s	= static pressure of gas stream (in. H_2O)
85.49	= pitot tube constant (ft/sec)([(lb/lbmole)(in. Hg)]/[(°R)(in. H_2O)]) $^{1/2}$
460	= conversion (°F to °R)
13.6	= conversion factor (in. H_2O/in Hg)

Volumetric Flow of Gas Stream - Actual Conditions

$$Q_a = 60 (V_s)(A_s)$$

where:

Q_a	= volumetric flow rate of the gas stream at actual conditions (acfm)
V_s	= average velocity of the gas stream (ft/sec)
A_s	= area of duct or stack (ft^2)
60	= conversion factor (sec/min)

Volumetric Flow of Gas Stream - Standard Conditions

$$Q_{std} = \frac{17.64(Q_a)\left(P_b + \frac{P_s}{13.6}\right)}{(T_s + 460)}$$

where:

Q_{std} = volumetric flow rate of the gas stream at standard conditions (scfm)
Q_a = volumetric flow rate of the gas stream at actual conditions (acfm)
T_s = average stack temperature (°F)
P_b = barometric pressure (in. Hg)
P_s = static pressure of gas stream (in. H_2O)
13.6 = conversion factor (in. H_2O/in Hg)
17.64 = ratio of standard temperature over standard pressure (°R/in.Hg)
460 = conversion (°F to °R)

Volumetric Flow of Gas Stream - Standard Conditions - Dry Basis

$$Q_{dstd} = Q_{std}\left(1 - \frac{B_{wo}}{100}\right)$$

where:

Q_{dstd} = volumetric flow rate of the gas stream at standard conditions, on a dry basis (dscfm)
Q_{std} = volumetric flow rate of the gas stream at standard conditions (scfm)
B_{wo} = moisture content of the gas stream (%)
100 = conversion factor

Ethylene Oxide Emission Rate (lb/hr)

$$E_{lb/hr} = \frac{(C_w)(MW)(Q_{dstd})(60)}{385.3 \times 10^6}$$

where:

$E_{lb/hr}$	= EtO emission rate (lb/hr)
C_w	= EtO concentration (ppmdv)
MW	= molecular weight of EtO (lb/lbmole)
60	= conversion factor (min/hr)
385.3	= volume occupied by one pound of gas at standard conditions (scf/lbmole)
10^6	= conversion factor (fraction to ppm)

Field Work Safety Plan

Site Safety Plan Booklet

Finalized: April, 2018

Introduction

Employee safety is the top priority of Montrose Environmental Group. All employees must be trained to mitigate the hazards faced each day. The site manager and project manager/lead are responsible to ensure all hazards have been proper identified and managed. All employees have Stop Work Authority in all situations where an employee feels they cannot perform a job safely or a task for which they have not been adequately trained.

The Site Safety Plan (SSP) has been developed to help assist Montrose test crews with identifying physical and health hazards that could harm our employees and determining how the hazards will be managed. Additionally, the SSP will help each crew manage the health of the employees by providing emergency procedures and information.

The booklet contains all the different safety forms that you may need in the field into one document. The SSP consists of the following:

1. A standardized, two-page, fillable pdf, form that is used as the Hazard Analysis and Safety Plan
2. Hazard Control Matrix - contains useful information on both engineering and administrative controls that a crew can use to reduce or eliminate the hazards they have observed plus applicable PPE that may be required
3. Tool Box Meeting Record – Keeps a daily record of the scheduled testing for the day and a short refresher of the hazards that were identified in the test location SSP and any hazard controls/PPE
4. Additional Forms
    a. Aerial Lift Inspection Form
    b. Heat Stress Prevention Form
    c. Extended Hours Form
    d. Safe Work Permit

An SSP for each location must be completed or at least started prior to mobilization and included as part of your Project Test Plan. Each test crew will then assess the hazards again while on-site looking for changes or new hazards. Once an SSP is completed, it will need to be reviewed before set up at each of your client's testing locations. Any day a SSP is not reviewed, a Tool Box Meeting will need to be completed.

The SSP is a living document. Each test crew should update the plan as new hazards are found. The client project manager should continually update their SSPs as new information and conditions result in new or changed hazards. The goal is to provide each crew with the most up-to-date hazard and safety information

MAQS Site Safety Plan

Client		Contact Name		Date	
Location		SSP Writer		PM	

Job Preparation

☐ Job Site Walk Through Completed ☐ Site Specific Training Complete ☐ Certified First Aid Person ______

☐ Site Walk Through Needed ☐ Site Specific Training Needed ☐ Other:

Facility Information/Emergency Preparedness

Plant Emergency # ______

On-Site EMS ☐ Yes ☐ No

EMS Location ______

Nearest Urgent Care Facility: ______

Identify and Locate the following:

Evacuation Routes ______

Severe Weather Shelter ______

Rally Point ______

Location of Eye Wash/Safety Shower:

Source Information (list type): ______

Flue Gas Temp. (^oF) ______ Flue Gas Press. ("H_2O)______ Flue Gas Components: ______

Flue Gas Inhalation Potential? ☐ Yes ☐ No

Describe Hazard Protection Plan:

Required PPE ☒ Hard Hats ☒ Safety Glasses ☒ Steel Toed Boots ☒ Hearing Protection

Additional PPE Requirements

☐ Hi-Vis Vests ☐ Harness/Lanyard* ☐ Goggles ☐ Personal Monitor Type: ______

☐ Metatarsal Guards ☐ SRL(s) ☐ Face Shield ☐ Respirator Type: ______

☐ Nomex/FRC ☐ Hot Gloves ☐ 4-Gas Monitor ☐ Other PPE:

Critical Procedures – check all that apply – "*" indicates additional form must be completed

☐ Hot Weather Work* ☐ Confined Space* ☐ Aerial Work Platform* ☐ Roof Work ☐ Scaffold

☐ Cold Weather Work ☐ Lock out/Tag Out ☐ Exposure Monitoring ☐ Other:

Working at Heights Management

Fall Protection Plan ☐ Fixed Guardrails/Toeboards ☐ Fall Protection PPE ☐ Warning Line

Describe Hazard Protection Plan:

Falling Objects Protection Plan

☐ Barricading ☐ Netting ☐ House Keeping ☐ Tethered Tools ☐ Catch Blanket or Tarp ☐ Safety Spotter

Describe Hazard Protection Plan:

MAQS Site Safety Plan

Fall Hazard Communication Plan

☐ Adjacent/Overhead Work ☐ Contractor Contact ☐ Client Contact

Describe Communication Plan:

Environmental Hazards - Weather Forecast

☐ Heat/Cold ☐ Lightning ☐ Rain ☐ Snow ☐ Ice ☐ Tornado ☐ Wind Speed ______

Describe Hazard Protection Plan:

Additional Work Place Hazards

Physical Hazards	Hazard Controls
☐ Nuisance Dust Hazards	☐ Dust Mask ☐ Goggles ☐ Other: ______
☐ Thermal Burn	☐ Hot Gloves ☐ Heat Shields ☐ Other Protective Clothing: ______
☐ Electrical Hazards	☐ Connections Protected from Elements ☐ External GFCI ☐ Other: ______
☐ Inadequate Lighting	☐ Install Temporary Lighting ☐ Headlamps
☐ Slip and Trip	☐ Housekeeping ☐ Barricade Area ☐ Other: ______

Describe Hazard Protection Plan:

List of Hazardous Chemicals

				Other Chemicals:
☐ Acetone	☐ Nitric Acid	☐ Hydrogen Peroxide	Compressed Gases	☐ ______
☐ Hexane	☐ Sulfuric Acid	☐ Isopropyl Alcohol	☐ Flammable Gas	☐ ______
☐ Toluene	☐ Hydrochloric Acid	☐ Liquid Nitrogen	☐ Non-Flammable Gas	☐ ______

Describe Hazard Protection Plan:

Wildlife/Fauna

Describe Hazard Protection Plan:

Crew Names & Signatures

Print Name	Signature	Date	Print Name	Signature	Date

Job Site Hazard Mitigation Plan

Hazard	Description	Engineering Controls	Administrative Controls	PPE
Ergonomic: Strains/Sprains	The manual movement of equipment to testing location can cause strains	• Eliminate manual “lifts” and use elevators and/or cranes when possible. Stairs can also be used where feasible. • Use lifting straps and locking carabiners to eliminate the need to continuously tie and untie loads. • Use pulley system to eliminate improper ergonomics when lifting and facilitate sharing of loads • Winches should be evaluated and used as much as possible to assist • Equipment should be staged on table or other elevated platform to assist with rigging, lifting and prevent bending over when securing equipment to hoist. • Maintain radio contact between ground and platform to ensure the process is going smoothly or if a break is needed.	• Stretching prior to and after lifting and lowering tasks to keep muscles and joints loose • Break loads into smaller more manageable portions • 3 man lift teams during initial set up and tear down w/2 below and one above • Job rotation and/or breaks during initial set up and tear down. • Discuss potential hazard and controls during tailboard meetings • Observe others and comment on technique	• Gloves, appropriate to task
Falling objects	When working from heights there is a potential of falling objects from elevated work platform striking someone or something below	• Ensure job area is barricaded off with hazard cones, caution tape and/or appropriate warning signs. Specific measures should comply with local plant rules. • Ensure a spotter is present during a lift or lowering of equipment. • Catch blanket should be used on the platform to prevent objects from falling through any grating. • Magnetic trays should be used to hold flange bots and nuts. • Tools should be tethered to platform or personnel uniform.	• Review hazards with any adjacent workers & the client so they understand the scope and timing of the job • Follow proper housekeeping practices by keeping the test location neat and orderly, keeping trash in bags and non-essential equipment stored when not in use. • Perform periodic job site inspections to ensure housekeeping is being observed • Review “grab and twist” method of handling tools and equipment between employees	• Hardhat • Steel toed boots • Work clothes

Job Site Hazard Mitigation Plan

Hazard	Description	Engineering Controls	Administrative Controls	PPE
Fall	Fall hazard exists when working from above 4' with no guardrails	• Verify anchor point • Warning Line system	• Review Working from Heights procedure prior to job • Maintain 3 points of contact when climbing stairs or ladders • Ensure all fall protection equipment has been inspected and is in good working order	• Harness and Lanyard
Burn	Flue gas temperature can be elevated and that can lead to hot temperature testing equipment. Hot pipes or other duct work at plant.	• Use heat resistant refractory blanket insulation to seal port once probe is inserted. Use duct tape to further seal the outer flange area of the port. • Use heat resistant blankets to shield workers from hot sources	• Work in tandem with partner to immediately fill sample port with heat resistant refractory insulation • Stand up wind of port when opening. If stack pressure is greater than 2" H_2O, a face shield is required. • Allow appropriate time to handle probes • Notify all team members at the test location when a probe is removed from a hot source and communicate to all crew members to exercise caution handling or working near the probe	• High temp. gloves • Long gauntlets • Long sleeve shirts • FRC
Atmosphere	Air concentrations could be above PEL	• Probe are to be sealed to prevent stack gases from leaking out • Ventilation, open all doors and window to dilute concentrations in work area • Vent analyzer or meter outside	• Stand up wind of ports • Use a gas monitor to ensure levels of contaminants are below PEL	• Respirator • SAR
Hearing	Production areas of plants could be high	NA	• Set up equipment or trailer as far away as possible from noise producing plant equipment.	• Ear plugs • Ear muffs (check with plant contact on exposure levels)

Job Site Hazard Mitigation Plan

Hazard	Description	Engineering Controls	Administrative Controls	PPE
Fire	High flue gas temps, chemicals, electricity could cause fire	• Fire extinguisher at job location	• Observe proper housekeeping • If conducting hot work, review procedures and permitting with site contact	• N/A
Weather	Conditions may pose significant hazards	• Weather App warning	• Lightning policy • JHA review of weather daily • Plant severe weather warning systems	• Appropriate clothing for conditions
Hot Weather	Extreme hot temperatures can cause physical symptoms	• Shade • Reduce radiant heat from hot sources • Ventilation fans	• Frequent breaks • Additional water or electrolyte replenishment • Heat Stress Prevention Form • Communication with workers • Share work load	• Appropriate clothing for conditions • Sunscreen
Cold Weather	Extreme cold temperatures can cause physical symptoms	• Hand warmers • Heaters • Wind blocks	• Calculate wind chill • Frequent warm up periods • Communication with workers	• Appropriate clothing for conditions
AWP	Overhead and ground hazards pose dangers	• Ensure all fall protection equipment has been inspected and is in good working order • Barricade off area where AWP is in use	• AWP pre-use inspection can identify problems with equipment • Site walk through can identify overhead and ground hazards	• Hardhat • Steel toed boots • Safety glasses • Harness/lanyard • Gloves
Scaffold	Fall hazard	• Yellow tagged scaffold may require harness & lanyard • Inspect harness & lanyard prior to use • Barricades • Netting	• Scaffold inspection prior to use can identify if scaffold meets OSHA regulations • Current scaffold training	• Hardhat • Steel toed boots • Safety glasses • Harness/lanyard

Job Site Hazard Mitigation Plan

Hazard	Description	Engineering Controls	Administrative Controls	PPE
Chemicals	Chemical fumes or splashing can cause asphyxiation or burns	• Chemical containers stored properly • Ventilation • Properly labeled secondary containers	• Spill kit training • Lab SOP • Good housekeeping • Personal hygiene	• Safety glasses • Chemical gloves • Lab coat • Ventilation • Goggles/Face shield as needed

Daily Tool Box Meeting Record

Client:__________ **Job No.:** __________ **Location:**____________________ **Date:**______

Scope of Work: ____

Changes in Hazards Any significant change in Hazards, update Site Specific Plan and sign off.

Site Specific Plan review

☐ ***Emergency Preparation*** ____ Rally Point ____ Alternate Exits ____ Obstacles in Route

☐ ***Source*** ____ Stack Temp. ____ Static Pressure ____ Flue gas contaminants

☐ ***PPE***

____ Hard Hats ____ Safety Glasses ____ Steel Toed Boots ____ Hearing Protection
____ Hi-Vis Vests ____ Harness* ____ Goggles ____ Personal Monitor Type: ______
____ Metatarsals ____ SRL ____ Face Shield ____ Respirator Type: ______
____ Nomex/FRC ____ Hot Gloves ____ 4-Gas Monitor ____ Other PPE: ______

☐ ***Critical Procedures***

____ Scaffold ____ Aerial Work Platform* ____ Confined Space*
____ LOTO ____ Roof Work ____ Exposure Monitoring

☐ ***Fall Protection*** ____ Guardrails ____ Fall Protection ____ Warning Lines

☐ ***Working at Heights***

____ Barricading ____ Tethered Tools ____ Netting
____ Housekeeping ____ Catch Blanket ____ Other: ______

☐ ***Barricades***

____ Morning Inspection ____________________
Printed Name Signature

____ EOBD Inspection ____________________
Printed Name Signature

☐ ***Communication*** ____ Adjacent/Overhead Work ____ Contractor Contact ____ Client Contact

☐ ***Weather***

____ Forecast ____ Lightning ____ Wind Speed ____ Wind Direction
____ Temperature ____ Cold ____ Hot*, *above 91° F use Heat Stress Prevention Form*
____ Fluids Reminder ____ Proper Clothing ____ Ice-Rain ____ Snowy

☐ ***Workplace Hazards*** ____ Dust ____ Electrical ____ Slips, Trips & Falls ____ Thermal Burn ____ Lighting

☐ ***Chemical***

____ Labeling ____ PPE ____ Cylinders Secured
____ Storage ____ Ventilation ____ Sample Storage

☐ ***Surroundings***

____ Site Traffic ____ Trucks ____ Forklifts
____ Construction ____ Cranes ____ Wildlife/Fauna
____ Machine Guarding ____ Chemical ____ Upwind/downwind Hazards

☐ ***Harness & Lanyard*** Inspected by:

____
Printed Name Signature

____
Printed Name Signature

____
Printed Name Signature

____
Tool Box Meeting Leader Signature

Test Crew Initials:

______ ______ ______
______ ______ ______
______ ______ ______
______ ______ ______

Notes:

*Requires additional form.

Montrose Air Quality Services -Daily Aerial Lift Inspection Form

All checks must be completed before operation of the aerial lift. This checklist must be used at the beginning of each shift or after six to eight hours of use.

General Information (Check All That Apply)

Manually Propelled Lift: _____________ **Self-Propelled Lift:** ______________________

Aerial Lift Model Number: ____________ **Serial Number:** ________________________

Make: ___________________________ **Rented Or Owned?** ____________________

Initial Description – Indicate by checking "Yes" that an item is adequate, operational, and safe. Check "No" to indicate that a repair or other corrective action is required prior to use. Check "N/A" to indicate "Not Applicable."

Number Item to be Inspected	Yes	No	N/A
A. Perform a visual inspection of all aerial lift components, i.e. missing parts, torn or loose hoses, hydraulic fluid leaks, etc. Replace as necessary	☐	☐	☐
B. Check the hydraulic fluid level with the platform fully lowered	☐	☐	☐
C. Check the tires for damage. Check wheel lug nuts for tightness	☐	☐	☐
D. Check the hoses and the cables for worn areas or or chafing.	☐	☐	☐
E. Check for cracked welds	☐	☐	☐
F. Check the platform rails and safety gate for damage	☐	☐	☐
G. Check for bent or broken structural members	☐	☐	☐
H. Check the pivot pins for security	☐	☐	☐
I. Check that all warning and instructional labels are legible and secure	☐	☐	☐
J. Inspect the platform control. Ensure the load capacity is clearly marked	☐	☐	☐

Initial Description – Continued

Number Item to be Inspected	Yes	No	N/A
K. Check for slippery conditions on the platform	☐	☐	☐
L. Verify that the Manufacturer's Instruction Manual is present inside the bucket	☐	☐	☐
M. Check the hydraulic system pressure (See manufacturer's specifications). If the pressure is low, determine the reason and repair in accordance with accepted procedures as outlined in the service manual	☐	☐	☐
N. Check the base controls for proper operation. Check switches and push buttons for proper operation	☐	☐	☐
O. Check the platform controls for proper operation. Check all switches and push buttons, as well as ensuring that the drive controller returns to neutral	☐	☐	☐
P. Verify that a fire extinguisher is present, mounted, and fully charged and operational inside the bucket	☐	☐	☐
Q. Verify that the aerial lift has headlights and a safety strobe-light installed and fully operational	☐	☐	☐
R. Verify that the aerial lift has a fully functional back-up alarm	☐	☐	☐

____

Print Name of Individual Inspecting Location Date
Aerial Location Date Lift

Heat Stress Prevention Form

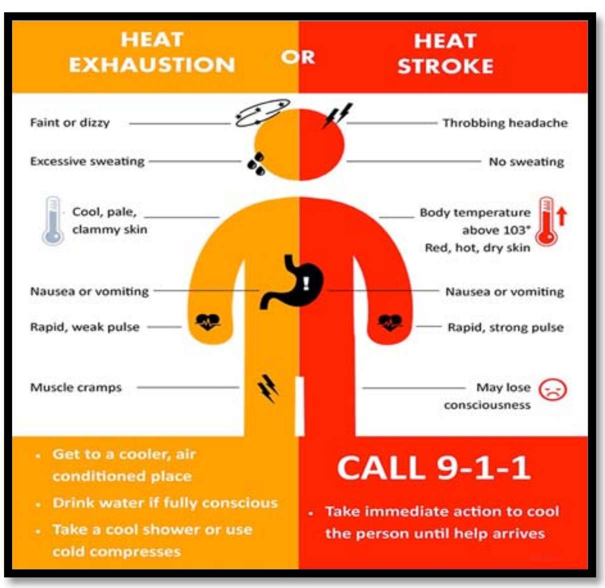
This form is to be used when the Expected Heat Index is above 91 degrees F. Keep the form with project documentation.

Project Location:____

Date:______________________________Project Manager:_________________________________

Expected High Temp:__________________Expected High Heat Index:_________________________

1. Review the signs of Heat Exhaustion and Heat Stroke
2. If Heat Index is above 91 degrees F:
    a. Provide cold water and/or sports drinks to all field staff. Avoid caffeinated drinks and energy drinks which actually increase core temperature. Bring no less than one gallon of water per employee.
    b. If employee are dehydrated, on blood pressure medication or not acclimated, ensure they are aware of heightened risk for heat illness.
    c. Provide cool head bands, vests, etc.
    d. Have ice available to employees.
    e. Encourage work rotation and breaks, particularly for employees working in direct sunlight.
    f. Provide as much shade at the jobsite as possible, including tarps, tents or other acceptable temporary structures.
    g. PM should interview each field staff periodically to look for signs of heat illness.
3. If Heat Index is above 103 degrees F:
    a. Employees must stop for drinks and breaks every hour (about 4 cups/hour).
    b. Employees are not permitted to work alone for more than one hour at a time without a break with shade and drinks.
    c. Employees should wear cool bands and vests if working outside more than one hour at a time.
    d. PM should interview each field staff every 2 hours to look for signs of heat illness.



Montrose Air Quality Services

Extended Hours Safety Audit

Project Number:________________________ Date:________ Time:______________

Whenever a project is going to extend past a 14-hourwork day, an Extended Hours Safety Audit to access the condition of their crew and the safety of their work environment must be completed. If a senior tech or a FPM is leading a project, they should confer with the CPM but they will need to get permission to proceed from the DM or RVP. CPMs need to get permission to proceed from the DM or RVP. Technical RVPs can authorize moving forward if they are in the field or if they own the project. DMs and RVPs may make the call in the field.

☐ Hold test crew meeting. Test Crew Initials:

"Extended or unusual work shifts may be more stressful physically, mentally and emotionally. Non-traditional shifts and extended work hours may disrupt the body's regular schedule, leading to increased risk of operator error, injuries and/or accidents."

The test leader should look for signs of the following in their crews:

- Irritability
- Lack of motivation
- Headaches
- Giddiness
- Fatigue
- Depression
- Reduced alertness, lack of concentration and memory

The test leader should assess the environmental and hazardous concerns:

- Temperature and weather
- Lighting
- Climbing
- Hoisting
- PPE (respirators, ect.)
- Pollutant concentration in ambient air (SO_2, H_2S, ect.)

☐ Notify DM or RVP Name:

The test leader must contact either the DM or RVP to discuss the safety issues that may arise due to the extended work period. During this time, they can come to an agreement on how to proceed.

Things to discuss are why the long hours?
Client or our delays?
Production limitations?
Impending Weather?

☐ Contact client

The test leader, DM or RVP should discuss with client any of our safety concerns, the client's needs and come to agreement on how to proceed. Discussion should also include the appropriate rest period needed before the next day's work can begin. The DM and/or a RVP must be kept in the loop on what the final decision is.

What was the outcome?

SAFE WORK PERMIT

A. WORK SCOPE (to be completed by MEG) – Check relevant box(es) to indicate type(s) of work.						
□ Hot Work	□ Line Break	□ Lock-out Tag-out	□ Other		**Permit Timing**	
Specific Location:					Date:	Time:
Equipment Worked On:					Valid Until	
Work to be Performed:					Date:	Time:

B. POTENTIAL HAZARDS (To be completed by MEG)			
□ Flammable	□ Harmful to breathe	□ Harmful by Skin Contact	
□ Verify process hazards have been reviewed			
C. PERSONAL PROTECTIVE EQUIPMENT (Check all additional equipment that is required)			
○ Tyvek Suit	○ Hearing Protection	○ H2S Monitor	○ Flash Hood
○ Rain Gear	○ Goggles	○ Safety Harness & Life Line	○ Life Vest
○ Chemical Resistant Gloves	○ Face shield	○ Tripod ER Escape Unit	○ Supplied Air Respirator
○ Rubber Boots	○ Organic Vapor Respirator	○ Fall Protection Equipment	○ Dust Respirator
○ Other:			
D. CHECK LIST (Check what has been completed)			
○ Joint Job Site Visit	○ Electrical Isolation Completed	○ Line Identified	○ Equipment Water Flushed
○ Equipment Depressurized	○ Isolated and locked out	○ Equipment Identified	○ Equipment Inert Gas Purged
○ Vents Opened & Cleared	○ Blinds in Place	○ Electrical Equipment Still Live	○ Written JSA Completed
○ Atmosphere Tested	○ Electrical Equipment Still Live	○ Equipment Still Live	○
Other:			
E. PRECAUTIONS (Check what must be completed PRIOR to commencing work)			
○ Cover Sewers	○ Scaffolding Inspection Done	○ Charged Hose/Area Wet	○ Communication Device(s)
○ Air Mover (Grounded)	○ Fire Extinguisher	○ Covered Cable Trays	○ Fire Watch
○ Barricade/Signs	○ Fire Resistant Blanket	○ Continuous Air Monitoring	
○ Other:			
○ Designated Fire Watch Individual and Start time (30 min after hot work):			
○ Fire Watch Complete (signature and time):			

F. HAZARD ANALYSIS (add additional information to form as necessary)			
	Job Steps	Potential Hazards	Hazard Controls
1.			
2.			
3.			
4.			
I VERIFY THAT THE ABOVE CHECK LIST "D" HAS BEEN COMPLETED, ALL OTHER CONDITIONS ("B", "C", "E", "F") ARE UNDERSTOOD AND WHEN MET, THE AREA IS SAFE FOR WORK TO COMMENCE.			
Name:	Signature:	Date:	Time:

Example Data Sheets

MONTROSE AIR QUALITY SERVICES, LLC

EPA Method 1

Sample and Velocity Traverses Datasheet

LOCATION ______________________________

Client	
Project No:	
Plant	
Date	
Technician	
Duct Diameter (in.)	
Port Diameter (in.)	
Port Length (in.)	
Port Type	
Distance A (ft)	
Distance B (ft)	
Distance A (Duct Diameters)	
Distance B (Duct Diameters)	

[N] [Up]

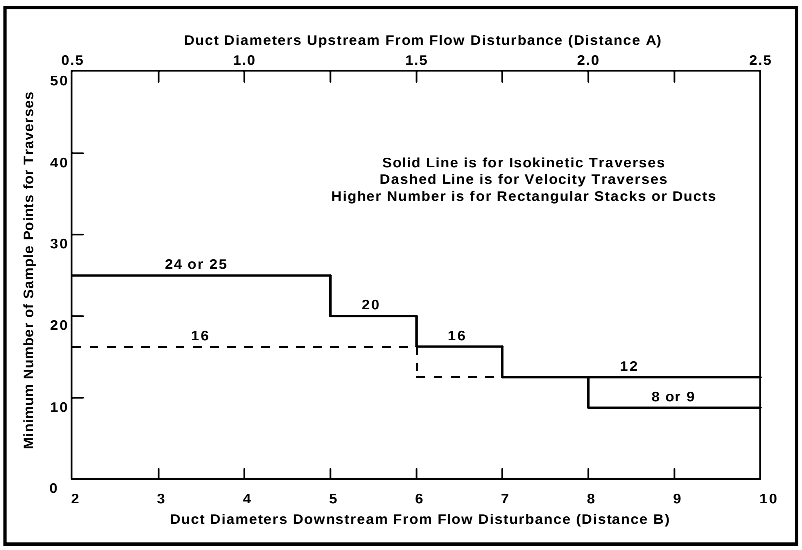
First point all the way [in] [out]

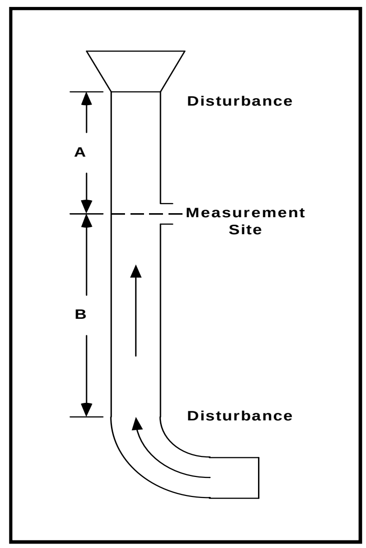
Gas flow [in] [out] of page

Cross Section of Duct

For rectangular ducts

$$ED = \frac{2LW}{(L+W)}$$





Location Schematic and Notes	**Traverse Point**	**Distance (in.)**
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	13	
	14	
Indicate sample ports, height from grade, types of disturbances, access, unistrut configuration, etc.	15	
Distance to point must include length of port	16	

MONTROSE AIR QUALITY SERVICES, LLC

EPA Method 2

Cyclonic Flow Traverse Datasheet

Page		of	

Client			
Project No.			
Plant			
Location		Duct size (in)	
Date		Port Length (in)	
Probe ID		Pitot Cp	

[N][Up]

First point all the way [in] [out]

Gas flow [in] or [out] of page

Cross Section of Duct

Run Number				Run Number				Run Number			
Start Time				Start Time				Start Time			
Stop Time				Stop Time				Stop Time			
Barometric (inHg)				Barometric (inHg)				Barometric (inHg)			
Static (inH_2O)				Static (inH_2O)				Static (inH_2O)			
Probe Operator				Probe Operator				Probe Operator			
Data Recorder				Data Recorder				Data Recorder			
Pre Leak Check				Pre Leak Check				Pre Leak Check			
Post Leak Check				Post Leak Check				Post Leak Check			
Traverse Point	Pressure ΔP @ 0^0 (in H_2O)	Angle α (< 20^0)	Notes	Traverse Point	Pressure ΔP @ 0^0 (in H_2O)	Angle α (< 20^0)	Notes	Traverse Point	Pressure ΔP @ 0^0 (in H_2O)	Angle α (< 20^0)	Notes
Total				Total				Total			
Average				Average				Average			

MONTROSE AIR QUALITY SERVICES, LLC
EPA Methods 2 and 4
Velocity and Moisture Datasheet

RUN NO. ________________

Page		of	

Client			
Project No.			
Plant			
Location		Date	
Meter Operator			
Probe Operator			

[N] [Up]

First point all the way [in] [out]

Gas flow [in] [out] of page

Cross Section of Duct

EPA Method 2

Barometric (inHg)		Probe ID	
Static (inH_2O)		Duct Dim. (in)	
Ambient Temp (^{0}F)		Port Length (in.)	

EPA Method 4

Meter ID		Yd		Pitot Cp	
Pre-Test Leak Check		cfm @		(in. Hg)	
Post-Test Leak Check		cfm @		(in. Hg)	
Start Time		Stop Time			
Water [ml]		Silica gel (g)			

Min/Point Elapsed Time	Orifice Setting ΔH (inH_2O)	Gas Sample Volume Initial [ft]	Impinger Outlet Temp (^{0}F)	DGM Inlet Temp (^{0}F)	DGM Outlet Temp (^{0}F)	Pump Vacuum (in Hg)	Notes
Total							
Average							

Run Number		
Start Time		
Stop Time		
Pre Leak Check		
Post Leak Check		
Points	Velocity Pressure ΔP (in H_2O)	Stack Temp (^{0}F)
Total		
Average ΔP		
Ave. Stack Temp.		

Run Number		
Start Time		
Stop Time		
Pre Leak Check		
Post Leak Check		
Points	Velocity Pressure ΔP (in H_2O)	Stack Temp (^{0}F)
Total		
Average ΔP		
Ave. Stack Temp.		

Circle correct bracketed [ ] units